A New Approach for Nuclear Data Covariance Generation

Luiz L. Leal[1], Nancy M. Larson[1], Herve Derrien[1], Toshihiko Kawano[2], Mark B. Chadwick[2]

[1] *Oak Ridge National Laboratory*
[2] *Los Alamos National Laboratory*

Nuclear data covariance information is required to assess uncertainties in design parameters in reactor applications. The error estimation of calculated quantities relies on uncertainty information reported in the basic nuclear data libraries such as the US Evaluated Nuclear Data Library, ENDF/B. The uncertainty files in the ENDF/B library are obtained from analyses of experimental data and are stored as variance and covariance. As is well known, the data representation in the ENDF library is in tabular format (for instance, cross sections as a function of energy) or represented as set of resonance parameters together with a nuclear formalism (for example, the cross section representation in the resonance region using the Reich-Moore representation). The objective of this paper is to describe a methodology developed at Oak Ridge National Laboratory (ORNL) for the generation of resonance parameter covariance matrices in the resonance region, and the methodology developed at Los Alamos National Laboratory (LANL) for the generation of covariance matrices in the higher-energy regions.

At ORNL, data evaluations in the resolved and unresolved resonance region are performed with the computer code SAMMY. The SAMMY evaluation in the resolved resonance region uses the R-matrix formalism, and in the unresolved range the evaluation is based on Hauser-Feshbach theory. Resonance parameters are obtained by fitting the experimental data using the generalized-least-squares technique from which the parameter covariance matrix is determined.

In a SAMMY evaluation, experimental data such as transmission data (or the corresponding effective total cross sections), capture cross sections, and/or fission cross sections are evaluated by taking into account the uncertainties in the experimental data. Various sources of experimental uncertainties exist, including normalization, background, time-of-flight, flight-path length, sample thickness, temperature, etc. All of these uncertainties are included in the evaluation process in order to properly determine the resonance parameter covariance matrix.

At LANL, the methodology for generating covariance data consists of least-squares fitting and model parameter adjustment. The least-squares fitting method calculates covariances directly from experimental data. The parameter adjustment method employs a nuclear model calculation such as the optical model and the Hauser-Feshbach model, and estimates a covariance for the nuclear model parameters.

In the full paper, both the ORNL methodology for generating the resonance parameter covariance matrices in the resolved and unresolved resonance region and the LANL scheme in the high energy region will be described. These methods have been applied to generate covariance data for Gadolinium isotopes ^{152}Gd, ^{154}Gd, ^{155}Gd, ^{156}Gd, ^{157}Gd, ^{158}Gd, and ^{160}Gd, respectively. The resulting covariance data have been effectively processed and used in benchmark calculations. Results of those benchmark calculations will also be reported.

Email: leallc@ornl.gov